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Structural Analysis of Helical Spring with Defect (Notch)

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ABSTRACT

The main of this work has to analysis the capacity of helical spring by using a materials i.e., structural steel and comparing the nature quality of spring (stiffness of spring, durability, reliability).There are many types defects present in the helical spring like Thermal Expansion, Vibration, Metal fatigue, Metal creep, Corrosion, Friction, Brittle fracture, Notch and so on. In which we have choosen a defect called Notch. We applied some load into the spring and checkout the deformations by regulating the position of notch from 1st layer to the last layer in all the three springs. In this we used two types of software i.e., CATIA V5 and ANSYS 2021 R1. We did analysis of all the layers of every spring and we calculate the total deformation in every layer of all the spring.

Keywords : ANSYS, Thermal Expansion, Vibration, Metal fatigue, Metal creep, Corrosion, Friction, Brittle fracture, Notch

I. INTRODUCTION

A spring is an elastic object that stores mechanical energy. Springs are typically made of spring steel. There are many spring designs. In everyday use, the term often refers to coil springs. In the year 1857, the steel coil spring was officially invented and was often used in the construction of chair seats. Steel structure was already been widely used. The high-rise, residential high-rise steel structures are very common in the developed countries. Structural steel is a category of steel used for making construction materials in a variety of shapes. Many structural steel shapes take the form of an elongated beam having a profile of a specific cross section. Structural steel shapes, sizes, chemical composition, mechanical properties such as strengths, storage practices, etc., are regulated by standards in most industrialized countries.The first used of steel structure in construction of countries can be traced back to the end of 18th century in British. A century later, when the French engineers built the famous Eiffel Tower, people began to try to use the steel structure to build the single-family house, thence the steel construction completely changed the previous model of building forms, building design concepts and methods.

In 1855, the Bessemer Method, created by Sir Henry Bessemer in England, made the production of steel more efficient. It allowed for the creation of steel with good tensile strength, however, wrought iron continued to be the more prevalent choice for iron-based building of the period. By 1879, inventor Sidney Thomas mastered a method to remove phosphorous from steel – increasing its quality and its possibilities. His "Basic Process" meant that steel could finally be produced more cheaply so, it's production rapidly grew. His method became popular in Europe and, by the 1880s, steel quality became more consistent.

History of Helical Spring: R. Tradwell filed a British patent, number 792, for the first coiled spring back in 1763. The word coil meant to wind cylindrically or spirally. This new patent was considered a step up from the leaf spring which had to be separated and lubricated often or it was very squeaky. The new coiled spring didn't have to be spread apart.In the year 1857, the steel coil spring was officially invented and was often used in the construction of chair seats.Ever since the inventions of these coil springs, springs have been used in everything from shoes to trampolines. They helped make the car industry what it is today. Springs are used in every type of machinery and they really do help make the world go around.

In the year 1857, the steel coil spring was officially invented and was often used in the construction of chairs seats. Even since the inventions of these coil springs. Springs have been used in everything from shoes to trampolines. They helped make the car industry what it is today.

A coil spring is a mechanical device which is typically used to store energy and subsequently release it, to absorb shock, or to maintain a force between contacting surfaces. They are made of an elastic material formed into shape of helix which returns to its natural length when unloaded.

Fig.1.2.1 Spring

A coil spring may also be used as a torsion spring in this case the spring as a whole is subjected to torsion about its helical axis. The material of the spring is thereby subjected to a bending moment, either reducing or increasing the helical radius. In this mode, it is Young's Modulus of the material that determines the spring characteristics.

Defect on Helical Spring: Raw materials defects, surface imperfections, improper heat treatment, corrosion, surface conditions and decarburisation act as stress raiser and lead to failure of spring usually at the inner surface of an active coil of the helical spring. Incorrect material Selection: There are various spring materials, and each of them has different characteristics that give it an advantage over others. These characteristics determine if they are more suitable in a particular application than another. Also, a spring material should be selected based on the features that are required in the application. Some of these features include water resistance, strength, corrosion resistance, temperature resistance, amongst others. To that effect, spring problems can be avoided if the right spring material for an application is selected.

Types of Spring Materials:

Titanium, Alloy Steel, Carbon Steel, Cobalt-Nickel, Stainless Steel, Nickel Base Alloy, Copper Base Alloy

Wrong Finoish selection: Spring problems can occur if these springs are susceptible to harsh conditions. However, springs finishes or coatings are used for cosmetic reasons since they prevent rusting. These coatings increase the spring's level of resistance to harsh elements. Much more, some springs are still made of stainless steel, which makes it necessary to use coatings on them – the use of coatings and finishes adds certain characteristics to these springs. Nonetheless, it is more important to consider the application the spring will be put into even before selecting the correct finish.

Spring Overstress due to Improper Design: Overstress in the spring is evident when its force is extended from what it was designed to handle. What causes this in the first place? You may wonder. But its a flaw in design! As a result, more stress or force being applied to the spring than what it can handle can cause it to break down. It's, however, worth noting that spring overstress can be curbed by specific preventative adjustments.

Spring Back due to Design: A stretched spring attempts to return to its original position after it has been released, and this is known as spring back. In a spring's design, its spring back must be taken into consideration in order to determine its proper bending angle. Here, the bends are not be made too close to an edge if not, the material that is on either side might get damaged. When that happens, it could tamper with the spring's integrity.

Wrong end Types: A spring's end type can affect its solid height, pitch, free length, number of active and total coils, and seating characteristics of the spring. That being the case, the end type should be selected after gaining an understanding of the various spring end options and their functions. The correct end type can also be selected after an understanding of the spring application demands.

II. Material Properties

In our investigation work structural steel is used. The material properties is shown below as table 2.1

Spring Height	120 mm
Spring Pitch	15 mm
Diameter of Spring	50 mm
Width of Spring	5 mm
Revolution	8
Load	500 N
Spring Height	120 mm
Spring Pitch	15 mm
Boundary Coditions	Spring is fixed from lower end

Table 2.1: Properties of Structural Steel

III. STRUCTURAL ANALYSIS

Geometric modeling of Helical Spring: The relationship of the specific strain energy can be expressed as it is well known that springs, are designed to absorb and store energy and then release it slowly. Ability to store and absorb more amount of strain energy ensures the comfortable suspension sy

Fig.3.1.1 Design of Helical Spring in 3D

Fig.3.1.2 Design of Helical Spring with Notch

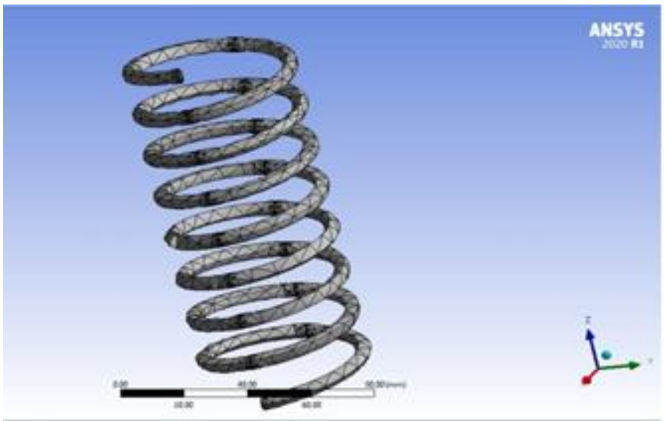


Fig.3.1.3 Mesh model of Helical spring

Notch Dimensions

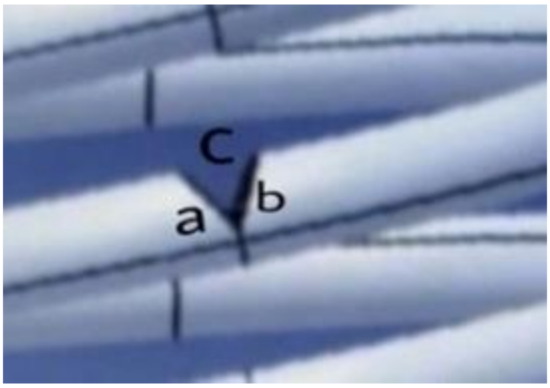
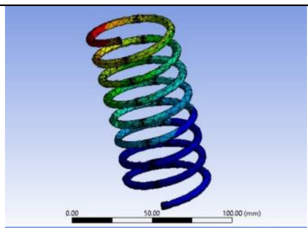
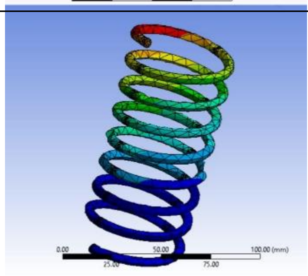
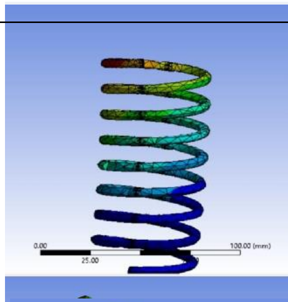
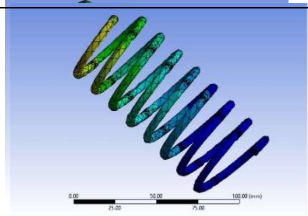
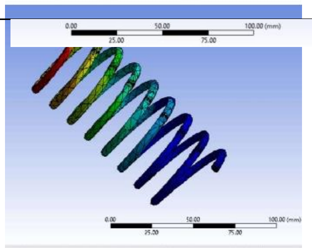


Fig.3.1.4 Notch of Spring

	Sides of Notch in mm		
	a	b	c
Notch 1	2.382	1.976	3.475
Notch 2	2.528	2.179	2.407
Notch 3	2.771	2.699	2.718
Notch 4	3.027	2.955	3.155
Notch 5	2.816	2.081	3.006
Notch 6	2.39	2.487	2.3449
Notch 7	2.029	1.928	2.249

Structural Analysis of Helical Spring

Structural Steel Spring with Notch (1st layer) x,y = (0,106.568)		Maximum Deformation d = 176.51mm
Structural Steel Spring with Notch (2nd layer) x,y = (0,91.303)		Maximum Deformation d = 174.92mm
Structural Steel Spring with Notch (3rd layer) x,y = (0,75.773)		Maximum Deformation d = 174.15mm
Structural Steel Spring with Notch (4th layer) x,y = (0,60.518)		Maximum Deformation d = 174.86mm
Structural Steel Spring with Notch (5th layer) x,y = (0,45.923)		Maximum Deformation d = 166.1mm

IV. RESULT DISCUSSION

In analysis of structural steel we saw that the layer 1 with notch location x,y (0,106.568) has the maximum the deformation value 176.51 mm among all the layer. The layer 5 with notch location xy (0,45.923) shows the minimum deformation 166.1 mm among all the layer. The other layer's i.e. layer 2 with notch location xy (0,91.303), layer 3 with notch location x,y (0,75.773) , layer 4 with notch location xy(0,60.518), layer 6 with notch location x,y(0,30.977) and layer 7 with notch location xy (0,16.253) shows the average deformation of structural steel.

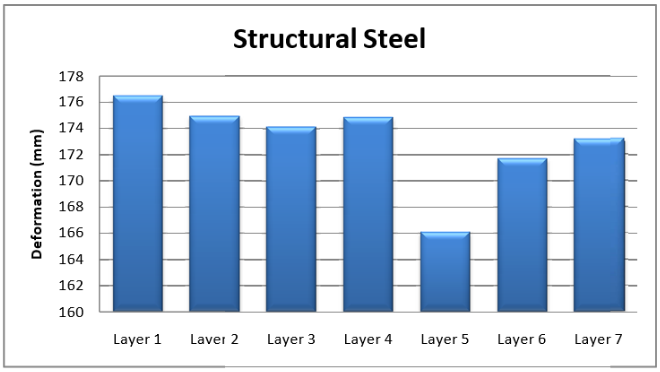


Fig.4.1 Maximum Deformation at Notch location

V. CONCLUSION

In the analysis of structural steel we saw that every layer showing different deformation value in which the layer 1 shows the maximum deformation value 176.51 mm. Layer 5 shows the minimum deformation value 166.1 mm and the layer 2, layer 3, layer 4, layer 6 and layer 7 shows the average deformation of structural steel.

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